

ABSTRACT.

The ore-bodies of the Zeehan mineral field are located between the township of Zeehan and the Devonian Heemskirk granite mass, some five miles west of Zeehan. Host rocks of the ores range in age from Younger Precambrian to Devonian, but most of the production has been from ore-bodies in Younger Precambrian to Lower Cambrian rocks.

A detailed mineralogical investigation has been made of the ores. The main objectives of this study were to compare the detailed ore mineralogy with the zonal relationships described by Twelvetyrees and Ward (1910), and to examine any evidence for the origin of the ores.

Detailed descriptions of the ore mineralogy are presented and summarized. The deposits are fissure lodes which, in the western part of the field consist largely of pyrite, sphalerite and quartz, and in the east consist largely of siderite and galena. Stannite is developed in one part of the field (Oonah Mine) and one small occurrence of nickel mineralization is present (Central Balstrup Mine). Tetrahedrite is an important mineral constituent of the ores, and antimony-bearing minerals are common in the central to eastern part of the field.

Some indications concerning temperatures of formation are provided by sulphide mineral assemblages. Analyses of sphalerite in pyrite - sphalerite assemblages indicate a

probable temperature gradient away from the Heemskirk Granite, possibly accompanied by a decrease in activity of sulphur.

Pyrite - arsenopyrite assemblages indicate an upper limit of approximately 500°C for the temperature of formation of several ore-bodies.

Variations in the sulphur isotopic composition of the ores are not completely conclusive but suggest that the ores were derived from the granite and that some of the sulphur was derived from crustal sulphate material assimilated, and reduced, during emplacement of the granite. Sulphur: selenium ratios (previously published by Edwards and Carlos, 1954) provide some evidence in support of this hypothesis.

Twelvotrees and Ward (1910) proposed a zonal arrangement of the ores around the margin of the Heemskirk Granite. This is briefly reviewed and a comparison made with the detailed ore mineralogy. The zonal arrangement is considered to be basically valid, although some amendments are suggested. A modified zonal arrangement consists of (1) a tin zone within the granite (2) a pyritic zone outside the granite, and passing into (3) a sideritic zone further east. Factors controlling the zoning are discussed.

On the basis of mineralogical and geochemical evidence, it is concluded that the sulphide ores of the Zeehan field were deposited from solutions which emanated from the Heemskirk Granite.

Suggestions are made for future mineralogical and geo-

chemical investigations on these ores.

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INTRODUCTION.

The Zeehan mineral field is located in the vicinity of the township of Zeehan ($145^{\circ}20'E$, $41^{\circ}53'N$), and forms part of a highly mineralized province in western Tasmania.

The western limit of the Zeehan field is marked by the south-eastern margin of the Heemskirk Granite mass, and the eastern limit by the Zeehan township. The western part of the Zeehan field is known as the Comstock area, and in some reports the field has been considered in two parts viz, Zeehan and Comstock. In this thesis, the term Zeehan field includes the mineral deposits of the Comstock area.

The tin ores occurring within the Heemskirk Granite form the adjacent Heemskirk mineral field.

Of the many previous reports concerned with the geology of the Zeehan field, the most important include early reports by Waller (1903, 1904) and Twelvetrees and Ward (1910), and the recent reports by Pitt (1962) and Blissett (1962). Summary descriptions have been provided in recent years by Edwards (1953) and McAndrew (1965).

Following the work of Twelvetrees and Ward (op. cit.) the Heemskirk and Zeehan fields became widely known for the zonal relationships proposed by these authors. In recent years some doubts have been expressed on the validity of this zoning.

The need for detailed mineralogical work was recognized by Twelvetrees and Ward (p.45), and it has again been

stressed by Blissett (op.cit.,p.87). The earliest mineralogical work on the Zeehan ores was done by Petterd (1910), who mentioned ⁿmay of the minerals found in the area in his ^tdescription of the minerals of Tasmania, and this was followed by the work of Stillwell (1931, 1947, 1950), Edwards (1951) and Williams (1958), who provided mineragraphic descriptions of specimens of ore from isolated mines in the district.

Since this study represents the first attempt at a comprehensive examination of the mineralogy of the ores of the Zeehan field, the main objectives have been (a) to provide a detailed description of the mineralogy of the ores occurring in the many mines in the district, (b) to compare the detailed mineralogy with the zonal theory as proposed by Twelvvetrees and Ward (1910), and (c) to examine any mineralogical evidence for the genesis of the ores.

A major difficulty encountered in this work has been the obtaining of adequate samples of the ore from the various mines. It is now many years since most of the mines were worked and the majority of the workings are flooded or are otherwise inaccessible. In most cases the mineralogy has had to be based on samples from the surface dumps, supplemented with samples from museum collections. Comparisons have been made with all available reports compiled while the mines were operating, and in most cases it is believed that the samples obtained for this study were representative.

A list of the minerals recorded in, or in association with, the ores of the Zeehan field is given below. This list includes some minerals not observed by the present author, but which have been recorded by previous investigators, in particular Petterd (1910) and Williams (1958).

Native Elements.

Gold	Au
* Silver	Ag
* Antimony	Sb

Sulphides and Arsenides.

Argentite	Ag_2S
Chalcocite	Cu_2S
Maucherite	$\text{Ni}_{12-x}\text{As}_8$
Galena	PbS
Sphalerite	ZnS
Chalcopyrite	CuFeS_2
Stannite	$\text{Cu}_2\text{FeSnS}_4$
* Voltzite	$\text{Zn}_5\text{S}_4\text{O}$
Pyrrhotite	Fe_{1-x}S
Niccolite	NiAs
* Hauchecornite	$(\text{Ni}, \text{Co})_7(\text{S}, \text{Sb}, \text{Bi})_8(?)$
Covellite	CuS
* Violarite	Ni_2FeS_4
Stibnite	Sb_2S_3
Bismuthinite	Bi_2S_3
* Kermesite	Sb_2S_2

Pyrite	FeS_2
Gersdorffite	NiAsS
—Ullmannite	— NiSbS
Rammelsbergite	NiAs_2
Marcasite	FeS_2
Arsenopyrite	FeAsS

Sulphosalts.

Pyrargyrite	Ag_3SbS_3
Proustite	Ag_3AsS_3
* Pyrostilpnite	Ag_3SbS_3
Tetrahedrite	$(\text{Cu}, \text{Fe})_{12}\text{Sb}_4\text{S}_{13}$
Bournonite	PbCuSbS_3
Boulangerite	$\text{Pb}_5\text{Sb}_4\text{S}_{11}$

Oxides.

Massicot	PbO
* Pyrolusite	MnO_2
Cassiterite	SnO_2
* Cervantite	$\text{Sb}_2\text{O}_4(?)$
* Stibiconite	$\text{Sb}_3\text{O}_6\text{OH}(?)$
Goethite	HFeO_2
Magnetite	Fe_3O_4
* Franklinite	ZnFe_2O_4

Halides.

* Cerargyrite	AgCl
* Embolite	$\text{Ag}(\text{Cl}, \text{Br})$

Fluorite	CaF_2
* Matlockite	PbFCl
* Atacamite	$\text{Cu}_2(\text{OH})_3\text{Cl}$

Carbonates.

Calcite	CaCO_3
Siderite	FeCO_3
Cerussite	PbCO_3
Malachite	$\text{Cu}_2(\text{OH})_2(\text{CO}_3)$
Azurite	$\text{Cu}_3(\text{OH})_2(\text{CO}_3)_2$
* Hydromagnesite	$\text{Mg}_4(\text{OH})_2(\text{CO}_3)_3 \cdot 3\text{H}_2\text{O}$

Sulphates.

Barite	BaSO_4
* Anglesite	PbSO_4
* Melanterite	$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$
* Goslarite	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$

Arsenates and Phosphates.

* Annabergite	$\text{Ni}_3(\text{AsO}_4)_2 \cdot 8\text{H}_2\text{O}$
Plumbogummite	$\text{Pb}_3\text{Al}_3(\text{PO}_4)_2(\text{OH})_5 \cdot \text{H}_2\text{O}$
Pyromorphite	$\text{Pb}_5(\text{PO}_4, \text{AsO}_4)_3\text{Cl}$
Mimetite	$\text{Pb}_5(\text{AsO}_4, \text{PO}_4)_3\text{Cl}$
* Evansite	$\text{Al}_3(\text{PO}_4)(\text{OH})_6 \cdot 6\text{H}_2\text{O}$

Antimonates.

* Bindheimite	$\text{Pb}_2\text{Sb}_2\text{O}_6(\text{O}, \text{OH})$
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Tungstates.

Wolframite	$(\text{Mn}, \text{Fe})\text{WO}_4$
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Silica Minerals.

Quartz	SiO_2
* Hyalite	$\text{SiO}_2 \cdot n\text{H}_2\text{O}$

Silicates.

Hisingerite	$\text{Fe}_2\text{Si}_2\text{O}_5(\text{OH})_4 \cdot 2\text{H}_2\text{O}(?)$
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* Denotes mineral not observed by present author.

In addition to the above list, the minerals crocoite, rhodonite, leadhillite, breithauptite, chloanthite and huascolite were also recorded by Petterd (1910), and bornite by Taylor and Burger (1951b). Petterd recorded the crocoite and rhodonite as reports requiring confirmation. The minerals referred to as leadhillite, breithauptite and chloanthite are now thought to have been incorrectly identified and are discussed further in subsequent sections. Huascolite is not a valid mineral name since it refers to a mixture of sphalerite and galena. There is also reason to doubt the identification of bornite by Taylor and Burger.

The mineral referred to as "jamesonite" in almost all previous reports on the Zeehan field has been identified as boulangerite.

Reid (1922) recorded the presence of small amounts of genthite, millerite and pentlandite in a narrow pyroxenite dyke between the Swansea Mine and the Silver Duke prospect, but this report could not be confirmed because of lack of samples.

HISTORY OF DEVELOPMENT.

In 1876 a party led by Charles Sprent, a government surveyor, left Waratah to investigate the mineral and agricultural potential of the west coast region of Tasmania. This party found traces of tin near Mount Heemskirk, and it was this discovery which led to the development of the Heemskirk tinfield.

Following a recommendation by Sprent, syndicates began sluicing alluvial tin in the vicinity of Mount Heemskirk. Further discoveries were made, and in 1879 vein deposits of tin were found. A boom period followed, and lasted until 1884. During this period of speculation a great deal of the money invested was wasted on the installation of expensive plants without adequate exploration. Exaggerated claims were made of the richness of the deposits, and in some cases inexperienced prospectors confused black tourmaline with cassiterite.

After the collapse of the field in 1884, mining operations became intermittent; the most successful mines in the field being Federation Mine and Mayne's Mine.

The Zeehan field was discovered in 1882 by Frank Long, who had been a member of Sprent's party in 1876. Tilley (1891) has recorded that Long found samples of argentiferous galena and traces of gold in a small creek near the present site of the Zeehan Post Office. Some leases were taken up but lapsed after 12 months through lack of financial support.

According to Pullen (1963) the causes of this disinterest were the inaccessibility of the field, the disappointing decline of the nearby Heemskirk field, and the low price of lead (£6-£7 per ton in 1883).

In 1887 a party consisting of George Bell, W. T. Bell and Joseph Wills discovered rich ore on the north-west side of Queen Hill. These further discoveries came at a time when there was great excitement over the rich discoveries at Broken Hill, NSW., and interest in the Zeehan field increased rapidly. Pullen (op.cit.) has recorded that over 200 claims were pegged out and registered within weeks of the discovery by Bell's party.

The field entered a boom period between 1889 and 1891 when the prices of silver and lead were relatively high (43½d. to 48d. per oz. for silver, and £13 - £15½ per ton for lead). The population grew from about 130 in 1889 to nearly 11,000 in 1893 (Pullen, op. cit.). However, transport of materials and ore to and from the field was difficult and costs were high. Until the Zeehan - Strahan railway was opened in 1892 access to the field was by means of the inadequate port of Trial Harbour and the difficult Trial Harbour - Zeehan track.

The boom period resulted in the development of a great number of small mines without sufficient regard to planning, and the subsequent failure of many of the small mines discouraged investment in the larger mines. Montgomery (1893)

recorded that in the Zeehan and Dundas areas over 80,000 acres of land had been taken up for mining purposes and that money available for exploration was thinly spread.

The Zeehan field received a heavy blow in 1891 when the Van Diemens Land Bank, which conducted most of the financial business of the Zeehan mines, closed its doors. Many of the small mines closed permanently and almost all mines were severely restricted by lack of capital. The price of silver fell in 1893, adding to the financial difficulties of the companies. The population began to decline as many miners left to go to other west coast mining fields, or to the West Australian goldfields.

Hopes were revived in 1898 when the Tasmanian Smelting Company (London) Ltd. opened a smelting plant about 2 miles from Zeehan, on the Zeehan - Strahan railway. The output of ore from the Zeehan field was not sufficient to keep the smelters fully occupied and the smelters also treated ore from the Hercules Mine at Williamsford, near Mount Read. A strike at the Hercules Mine from 1905 to 1907 cut off this supply and the smelters closed in 1907. The plant re-opened again in 1911 but the Zeehan field was being rapidly depleted in shallow ore and the smelters again closed in 1914. The field then became virtually abandoned and the population declined rapidly. The most recent census (1961) recorded a population of 780 for the township of Zeehan. *

* Figure supplied by Bureau of Census and Statistics.

Most of the workings were shallow and were abandoned when the rich shoots of galena gave way to lower grade ore at depth. Very few workings exceeded 300 feet in depth.

Further exploratory work has been carried out from time to time and some of the mines have been operated intermittently. The Montana S. L. Mine, formerly the May Queen workings, were re-opened in 1939 but closed again in 1941. Operations commenced again on a small scale in 1950 but ceased in 1958.

Following exploration work by North Broken Hill Ltd. and Broken Hill South Ltd., the Oceana Mine was re-opened in 1950 by Zeehan Mines Pty. Ltd. Ore was produced from 1954 to 1960, when the mine closed again.

The only active mining in the Zeehan field at present consists of smallscale operations by Mr. D. Dunkley at the Stormsdown Mine.

The field is covered by exploration and prospecting licences held by Placer Prospecting Pty. Ltd., Mr. C. Loftus Hills, Comstaff Pty. ^{Ltd.} and Pickands Mather and Co. International.

SUMMARY OF THE GEOLOGY.

Field mapping has not been undertaken as a part of this project, and the following summary of the geology of the Zeehan field does not contain original observations by this author. The summary is based largely on the regional mapping by Blissett (1962) and the more detailed mapping by Pitt (1962).

Figure 1 is the Department of Mines', 1 mile to the inch geological map of the Zeehan Quadrangle (Blissett, 1962), and Figure 2 is a more detailed geological map of the Zeehan area, adapted from Blissett. The geology of the area is also illustrated by the cross-section in Figure II.

For a comprehensive account of the geology of Tasmania in relation to mineralization, the reader is referred to Solomon (1965).

The oldest rocks in the Zeehan field are those known as the Oonah Quartzite and Slate. This formation, of unknown thickness, is generally regarded as Upper Proterozoic in age but may range up into the Lower Cambrian. The Oonah Quartzite and Slate consists of white and pale grey quartzites which alternate with dark grey and black shales and slates.

Spilitic lava and tuffs in association with shales, sandstones and dolomites are exposed in a localised area to the north and west of Zeehan. These rocks outcrop along a curved belt extending from a point near the Sylvester mine to a point about one mile north-north-east of the Montana S. L. Mine,

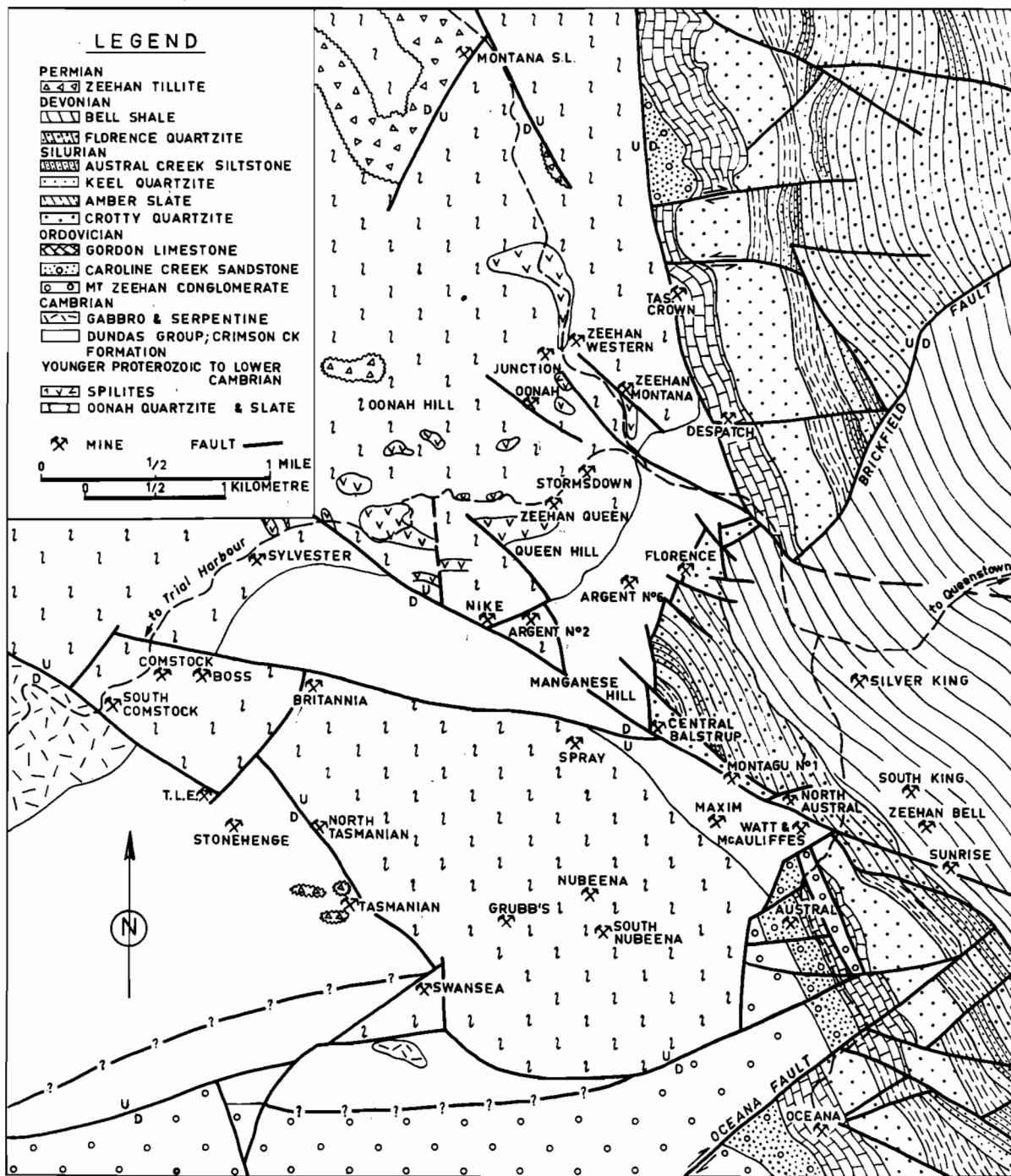


FIGURE 2 Detailed Geology, ZEEHAN AREA (adapted from Blissett, 1962)
 Mines not shown on this map may be found in Figure 1.

but are most common in the vicinity of the Zeehan - Montana, Oonah and Zeehan Queen mines. Hills and Carey (1949) named the volcanics the Montana Melaphyre Volcanics, and the sediments the Nubeena Quartzites and Slates, but Blissett (1962) and Spry (1964) have included these within the Oonah Quartzite and Slate. Pitt (1962) placed the volcanics and associated sediments above the Oonah Quartzite and Slate, and proposed the term Montana Volcanics for both the volcanics and the sediments. The age of these rocks is generally regarded as Lower Cambrian or Upper Proterozoic.

Overlying the Oonah Quartzite and Slate and the Montana Volcanics are Cambrian sediments with minor associated volcanics, which outcrop in Austral Valley, Argent Flat and to the west of Manganese Hill. Twelvetrees and Ward (1910) referred to these as "Keratophyric Tuffs and Breccias", a term which has often been abbreviated to "Keratophyric Tuff".

There is some divergence of opinion on the correlation of this formation. Pitt (1962) considered that the "Keratophyric Tuff" overlies the Montana Volcanics unconformably and can be correlated with the lower part of the Dundas Group in the type area at Dundas (see Elliston, 1954, and amended succession in Banks, 1962a). Pitt reported that the assemblage consists of sandstone, greywacke, laminated and banded shale and slates, and minor basic lava and tuffaceous material. Pitt considered the age to be Middle Cambrian and, because of the low content of tuffaceous material, proposed that the term "Keratophyric Tuff" be replaced by the term

"Dundas Group Correlate".

Blissett and Gulline (1961) and Blissett (1962) have correlated part of the "Keratophyric Tuff" with the Crimson Creek Formation (Crimson Creek Argillite of Taylor, 1954b) of the Pieman River - Huskisson River area. These authors correlated the remainder of the "Keratophyric Tuff" (viz, the slates in Summit Cutting on Comstock tram, west of Manganese Hill) with the Dundas Group. Blissett (1962) considered that the Crimson Creek Formation, of Lower to Middle Cambrian age, conformably overlies the Oonah Quartzite and Slate and passes up into the Dundas Group, of Middle to Upper Cambrian age.

The Cambrian beds are succeeded conformably or disconformably by the Ordovician Junee Group, consisting of the Mount Zeehan Conglomerate, Caroline Creek Sandstone, and Gordon Limestone. The Mount Zeehan Conglomerate, which is equivalent to the Owen Conglomerate of the West Coast Range, varies in thickness and lithology over short distances. The maximum thickness is 1,500 feet (at Mount Zeehan), and the beds consist mainly of coarse conglomerate with pebbles, cobbles and boulders of quartzite in a reddish matrix of quartz grit.

The Caroline Creek Sandstone reaches a maximum thickness of 1,200 feet in the Zeehan area, and consists of pale grey grit, quartzite and sandstone. This formation is equivalent to the Moina Sandstone (see Banks, 1962b) and the latter name was used by Blissett (1962).

The Gordon Limestone is exposed only occasionally in the

Zeehan area, as it has been largely decomposed into grey and black clay forming swampy flats. Where this formation does outcrop, it consists of grey to black limestone, sometimes arenaceous.. Blissett (1962) estimated the thickness of Gordon Limestone in the Zeehan area as 900 to 1,000 feet, but Pitt (1962) estimated it to be approximately 1,680 feet.

Following the Junee Group sediments, probably with disconformity, are the sediments of the Eldon Group of Silurian and Lower Devonian age. The Eldon Group was defined by Gill and Banks (1950) and later modified by Banks (1962c) and Blissett (1962). The amended succession and thicknesses are given below. The thicknesses refer to the type area at Eden Siding (about 10 miles south of Zeehan), with the exception of the Austral Creek Siltstone, for which the type area is near the junction of the Little Henty River and Austral Creek. Thicknesses estimated by Pitt (1962) in the Zeehan area are shown in parentheses.

Lower Devonian	{	Bell Shale	Over 1,400 ft. (1,500 ft.) (800 ft.)
		Florence Quartzite	1,600 ft. (900 ft.)
Silurian	{	Austral Creek Siltstone	200 ft. (360 ft.)
		Keel Quartzite	200 ft. (130 ft.)
		Amber Slate	800 ft. (620 ft.)
		Crotty Quartzite	1,600 ft. (950 ft.)

The Crotty Quartzite contains the coarsest sediments of the Eldon Group, and consists of pale quartzite and sandstone with pebbly bands, and bands of shale or slate.

The Amber Slate consists of greenish-grey shale or slate, siltstone, and bands of fine quartzite.

The Keel Quartzite is a white quartzite, usually fine-grained but with some coarse bands.

The Austral Creek Siltstone was defined by Blissett(1962) to include the beds between the Keel Quartzite and the Florence Quartzite. The formation consists of greenish-grey and bluish-grey laminated silty shale, siltstone and fine quartzite. Pitt (1962) used the term "Hill Shale" to describe this formation.

The Florence Quartzite is a highly fossiliferous formation consisting largely of calcareous sandstone and greenish-grey siltstone.

The Bell Shale consists of siltstone, shale, and interbedded quartzite. Pitt (1962) proposed that the base of the Bell Shale be redefined to include the Silver King Formation between the Florence Quartzite and the Bell Shale. Pitt described the Silver King Formation as approximately 800 feet in thickness and consisting of "interbedded olive grey to medium grey quartzose arenites and dark grey lutites...". These rocks outcrop in the vicinity of the Silver King Mine. The Bell Shale, as redefined, would have a thickness of approximately 1,500 feet in the Zeehan area, according to Pitt.

Sedimentation ceased with the Tabberabberan Orogeny during the Lower to Middle Devonian.

The Permian System is represented by the Zeehan Tillite, which occurs in the vicinity of Montana S. L. Mine. The

tillite in this locality is less than 50 feet thick. Smaller patches occur north of Conah Hill and near the Tasmanian and Swansea Mines. According to Blissett (1962) the tillite is a "stiff yellowish-weathering blue-grey or greenish-grey clay, with unsorted fragments of quartz, quartzite and sandstone, sometimes striated, and occasionally shale".

In the Middle to Upper Cambrian, widespread basic and ultra-basic sills and dykes were intruded. Many of these are extensively serpentized. A thick transgressive sill in the Comstock area has intruded rocks which Blissett (1962) has correlated with the Crimson Creek Formation. The northern part of this intrusion has been partially serpentized and dolomitized, and contains the Tenth Legion magnetite deposit. Minor nickel mineralization is associated with the Cambrian ultrabasic rocks (Williams, 1958).

The Tabberabberan Orogeny in Tasmania was followed by extensive intrusion of granites, accompanied by mineralization. During this period the Heemskirk granite mass was emplaced. This body has a surface area of between 40 and 50 square miles, and consists of two mineralogically similar types, viz. white and red, the colour difference being due to the colour of the orthoclase feldspar. A grey granite is also developed along contacts of the white and red.

The white granite contains abundant tourmaline, some of which is in the form of quartz-tourmaline modules. Veins of quartz, quartz-tourmaline, and greisen contain cassiterite and some associated sulphide mineralization. The red and

white granite are both transgressed by compositionally similar dykes of aplite and pegmatite.

Rb-Sr age determinations by Brooks and Compston (in press) have shown the granite to be of Upper Devonian Age (Brooks, pers. comm.).

The Heemskirk mineral field consisted of workings on alluvial and vein cassiterite deposits, almost entirely within the margins of the granite. Detailed descriptions of the various mines were given by Waller (1902a) and Waterhouse (1915, 1916).

The granite is bordered mainly by Oonah Quartzite and Slate but also partly, in the south, by (?)Cambrian volcanics. The contact metamorphic aureole in the vicinity of Trial Harbour has been described by Green (1964). Contact metamorphism of the Oonah Quartzite and Slate is not extensive, the only characteristic assemblage being an andalusite-bearing pelitic hornfels. However, contact metamorphism of the (?)Cambrian volcanics has given rise to a greater variety of assemblages, including (1) lime and ferromagnesian rich (hypersthene(?) - labradorite; diopside - actinolitic hornblende - labradorite) (2) magnesian rich (cordierite - hypersthene; cordierite-anthophyllite) (3) ultrabasic (olivine or pleonaste).

According to Blissett (1962), there are no major angular unconformities from the Upper Proterozoic to Lower Devonian, and the major structures in the Zeehan region were produced by Tabberabberan movements and by post-Permian epeirogenic

block faulting.

Blissett (op. cit.) demonstrated the presence of post-Permian faulting in the Zeehan region, but stated that precise dating of the movements is not possible. In a study of available reports and mine plans, Blissett found evidence for post-mineralization faulting, which he considered to be possibly Tertiary. According to Blissett, this faulting was particularly intense in the north-eastern part of the field and caused dislocations of several ore-bodies. The No. 8 Lode of the Zeehan-Western Mine, for example, was dislocated by a fault, for which Waller (1904) estimated an eastern upthrow of 200 feet. Blissett considered that the (?) Tertiary faulting in the Zeehan area was at least partly controlled by Tabberabberan structures.

The Zeehan ore-bodies are fissure veins which, according to Blissett, formed along zones of faulting, shearing and fracture resulting from Tabberabberan movements.

Twelvetrees and Ward (1910) noted that there was very little sign of alteration of the wall-rocks of the ore-bodies.

The Heemskirk Granite has been generally accepted as the source of the ores of the Zeehan field, but this assumption has been questioned on several occasions in recent years.

PRODUCTION FIGURES.

The Zeehan field produced approximately 200,000 tons of lead, 27,000,000 ozs. of silver, and 2,700 tons of zinc.

Production figures for the individual mines are listed in Table 1. This table has been compiled from data in Blissett (1962) and includes estimates made by Blissett where the recorded production figures of mines were incomplete. More detailed production figures may be found in Blissett.

TABLE 1.

Production figures for mines in Zeehan field.

Mine or prospect	Lead (tons)	Silver (ozs)	Zinc (tons)	
Comstock and				
South Comstock	1,625	165,000	2,100	
Silver Stream	165	9,200		
Doric	0.44	30		
Sylvester	274	26,560		
Boss	70	6,500		
Susannite	20	3,500		
Britannia	See Spray Mine			
T.L.E.	203	30,031	1	
Stonehenge	30	2,700		
North Tasmanian				
and Tasmanian	720	41,299	8	Cad-
Swansea	1,319	35,630	570	mium 40 tons.
Grubb's	See Colonel North			
Nubeena and				
South Nubeena	375	49,000		
Colonel North	1,549	128,075		
(including Grubb's)				
Spray *	41,700	6,456,674		
Argent Mines				
(nos. 2, 5, 6)	4,248	561,110		
Mount Zeehan	1,540	166,850		
Nike	2,149	225,830	7.8	

TABLE 1(continued)

Mine or prospect	Lead (tons)	Silver (ozs.)	Zinc (tons)
Florence	10,200	1,400,000	
Stormsdown			Tin 5 tons
Zeehan Queen	16,532	1,973,746	**
Oonah	11,724	2,050,135	**
Junction (including			Copper 941 tons
Hanrahan's Adit)	15	8,728	
Zeehan-Western	26,300	4,800,000	
Zeehan-Montana	49,580	7,058,122	
Montana S.L.	2,304	279,348	
Tasmanian Crown	113	15,738	
Silver King			Copper
and South King	5,000	350,000	4 tons
Zeehan Bell	600	27,500	
Sunrise	36	4,760	
Maxim	60	10,000	
Watt and McAuliffe's } North Austral Austral	1,050	83,000	50
Montagu No.1.	115	1,500	
Central Balstrup	12	1,250	
Oceana	14,902	614,981	12.8

* Production figures for Spray Mine probably include production from Britannia Mine, which produced an estimated maximum of 400 tons of galena ore.

** Tin also produced but production figures not available.

MINERALOGY OF THE ORES OF THE ZEEHAN FIELD.

Mineragraphic examinations have been made of ore specimens from as many of the mines and prospects as possible, and mineralogical descriptions for the various mines are presented in this section. The mineralogy is treated in this way because an important overall consideration is the question of a zonal arrangement of the ores. It is considered that a description of the mineralogy of the ore from each mine, or group of closely related mines, will provide the most satisfactory basis for a discussion of any regional zoning pattern.

An additional reason for providing these mineralogical descriptions is that, because of the difficulty in obtaining representative samples, a detailed mineralogical record of the area is considered to be necessary. As mentioned earlier, the majority of the samples used in this study have been obtained from surface dumps near the various workings and from museum collections. These surface dumps are subjected to severe weathering conditions and many dumps have also been a ready source of supply for mineral collectors. In the not-too-distant future the dumps will not be capable of providing suitable material for mineralogical purposes, and, in fact, this already is the case for some of the mines.

Should any of the mines in the Zeehan field be re-opened, it will be possible for more detailed mineralogical work to be carried out on individual ore-bodies than has been possible in this study.

The emphasis in this section is on the mineralogical

constitution of the ore from various mines and prospects. Comparisons are made with early reports dealing with the Zeehan field, in particular Montgomery (1890, 1893, 1895), Twelvetreets (1901a), Waller (1903, 1904) and Twelvetreets and Ward (1910), in an attempt to judge whether or not the samples are representative. Brief notes on the geological setting of each mine are also included, and these are based on the work of Blissett (1962). In discussing mineral assemblages it is necessary to mention the textural relationships of the minerals, but the interpretation of the textures is considered in a subsequent section.

Included with the mineralogy of the various mines are lists of the observed mineral assemblages. These are divided into three arbitrary categories on the basis of estimated abundance of the assemblages in the specimens examined. The minerals occurring in each assemblage are given in alphabetical order. The common assemblages are listed in estimated order of abundance of the assemblages, but the infrequent and rare assemblages are listed in alphabetical order.

The ores have been examined by means of polished sections and thin sections, and reference is made to particular specimens by use of the section number. These numbers refer to the Tasmanian Museum catalogue of polished and thin sections: the prefix "P" indicates a polished section and "Ts" a thin section. A list of all polished and thin sections, together with the specimen numbers of the corresponding hand specimens, is provided in the appendix. Reference is also occasionally

made in this section to hand specimens from the collections of the Tasmanian Museum, Hobart, the Queen Victoria Museum, Launceston, and the University of Tasmania. In each case the appropriate accession number is quoted.

Comstock and South Comstock Mines.

The workings which constitute the Comstock and South Comstock Mines are located in the western part of the Zeehan field. All of the workings are found on either side of the Trial Harbour road between the abandoned tram lines known as the Comstock tram and the Tasmanian tram.

Blissett (1962) has described the lodes as fissured veins or irregular lenses, occurring in a variable succession of disturbed and contorted mica-schist, phyllite and slate, with quartzite and sub-greywacke. The succession is considered by Blissett to represent the upper part of the Oonah Quartzite and Slate.

Reports by Twelvetrees (1901a), Waller (1903), and Twelvetrees and Ward (1910) all refer to the composition of ores in lodes in the Comstock and South Comstock Mines as consisting of sphalerite and galena with pyrite. Although the ratio of sphalerite to galena varied through the lodes, it appears that sphalerite was the more abundant overall. According to Montgomery (1893), the average assay of 298 tons of galena ore was 50% lead and 60 ozs. of silver per ton. Twelvetrees (1901a) reported that the average content of 387 tons of ore taken from the Comstock Mine was 52% lead and 63 ozs silver per ton. Twelvetrees also reported that hand-picked samples of galena from the South Comstock Mine assayed 84% lead and 114 ozs. 6dwts. 16grs. silver per ton.

Four lodes have been reported in the workings of these mines. These are No.1 (Main) Lode, No. 2 Lode, East

(Allison's) Lode and West Lode. The mineralogy of all four lodes was similar, at least as far as can be judged for the major constituents.

Petters (1910) recorded the occurrence of goslarite, bisingerite and hydromagnesite in the Comstock Mine; all are apparently of secondary origin.

Samples of the ore from surface dumps around the workings consist essentially of assemblages of pyrite, sphalerite and galena in a gangue of quartz and siderite. Minor constituents observed in polished sections of the ore were chalcopryrite, arsenopyrite, pyrrhotite, tetrahedrite, boulangierite and marcasite. Some hand specimens show a poorly-defined banding of the pyrite, sphalerite and galena.

Pyrite is present in the ore as idiomorphic crystals up to 0.5cm across, invariably showing signs of apparent replacement by galena and sphalerite. Inclusions of pyrrhotite and chalcopryrite are common within the pyrite crystals, and the textural relationships indicate incipient replacement of the pyrite. One specimen (P. 159) revealed minute inclusions of a gangue mineral within the pyrite. These inclusions show a definite relationship to the crystal outlines and the maximum size of the individual inclusions is 0.0005mm.

Small idiomorphic crystals of arsenopyrite are closely associated with the pyrite, and also appear to have undergone partial replacement by galena. In some specimens (eg. P. 365) marcasite is present as a fine intergrowth within the pyrite.

Sphalerite is present in ore from the Comstock area as

massive dark material and as narrow bands associated with pyrite and galena.

Galena appears to have partially replaced sphalerite where the two minerals are in contact. Exsolution bodies of pyrrhotite and chalcopyrite are common within the sphalerite, and often occur as chains of minute inclusions aligned along crystallographic planes. The chains of pyrrhotite inclusions consist of elongate blade-like bodies ranging from 0.001mm up to 0.01mm in length (Plate 1, No. 1). The chains of chalcopyrite inclusions consist of similarly shaped bodies but are slightly finer, the lengths being from 0.001mm up to 0.005mm. Both the pyrrhotite and chalcopyrite also occur within the sphalerite as randomly distributed bodies of irregular outline; the size of these bodies is generally no greater than 0.03mm. Composite chalcopyrite-pyrrhotite inclusions were occasionally observed within the sphalerite.

One specimen of Comstock ore in the collection of the Tasmanian Museum was labelled "huascolite" (279/P.106). This specimen was originally in the collection of W.F. Petterd and huascolite was described by Petterd (1910) as a sulphide of lead and zinc. The material is actually sphalerite containing inclusions of galena which vary in size from 0.01mm up to 0.15mm. Other inclusions within the sphalerite in this specimen are pyrite, pyrrhotite and chalcopyrite.

Galena is often present in the banded ore as narrow bands of fine grained material associated with the pyrite and sphalerite, but also occurs as a minor constituent associated

with the more abundant massive sphalerite and pyrite. Less commonly the galena itself is found as massive crystalline material (eg.X2926), with individual crystals up to 0.5cm.

A noticeable feature of all galena examined from the Comstock area is the low content of exsolution bodies of the minerals observed in galena from other mines in the Zeehan field. Tetrahedrite and boulangerite occur only as occasional small inclusions (0.01mm) in the galena, and bournonite was not observed.

Assemblages of ore minerals.

Common:	Pyrite - sphalerite
	Galena - pyrite
	Galena - sphalerite
	Chalcopyrite - sphalerite
	Pyrrhotite - sphalerite
	Galena - pyrite - sphalerite
Infrequent:	Arsenopyrite - galena
	Arsenopyrite - galena - pyrite
	Arsenopyrite - pyrite
	Arsenopyrite - sphalerite
	Boulangerite - galena
	Chalcopyrite - pyrite
	Galena - tetrahedrite
	Marcasite - pyrite
	Pyrite - pyrrhotite
Rare:	Arsenopyrite - galena - sphalerite
	Boulangerite - pyrrhotite - sphalerite
	Boulangerite - sphalerite
	Chalcopyrite - pyrrhotite - sphalerite
	Galena - pyrrhotite
	Galena - pyrrhotite - sphalerite

Silver Stream Mine.

The workings of the Silver Stream Mine, also known as W. Thomas' Section, are located between the Tenth Legion magnetite deposit and the Comstock Mine. The country rocks were described by Blissett (1962) as "intensely disturbed and highly weathered schist, slate and sandstone of the Conah quartzite and Slate - - -".

Early reports of the Zeehan field give no clear picture of the composition of the ore bodies in the Silver Stream Mine. It is apparent that sphalerite, galena, pyrite and chalcoppyrite were common minerals, but it is difficult to get any indication of relative proportions.

Montgomery (1893) in describing the mine workings referred to "No. 1 Lode" at a depth of 532 feet as consisting of galena and sphalerite with some chalcoppyrite and pyrrhotite. Waller (1903) reported that the principal metallic minerals in this lode were sphalerite, galena and pyrite, and also described a "copper" lode which was encountered in an adit south-west of the main workings. This lode was described as consisting of "kaolin, steatite and gossan, much stained with copper carbonate." A bulk sample of this material, taken over a width of 3'6" gave a return of 9.3% Cu and 1oz. 19dwts. 4grs. of silver. Twelvetrees and Ward (1910) referred to the Main Lode as consisting of sphalerite and galena in a clay matrix with minor chalcoppyrite, pyrite, magnetite and garnet. Barite was reported to occur as "bunches in the lode-matter" (Twelvetrees and

Ward, p.49).

The specimens obtained for this present examination were very few; apart from specimens of poorly mineralized material collected from the dumps of the main workings, the only other sample available was one specimen in the collection of the Queen Victoria Museum, Launceston. This specimen (no. QM:33:838) consists essentially of sphalerite, chalcocite and pyrite, with minor amounts of pyrrhotite, galena, marcasite magnetite and boulangerite in a gangue of quartz and siderite.

The sphalerite in this specimen is extensively intergrown with chalcocite, and contains abundant exsolution bodies of chalcocite and pyrrhotite. These bodies occur in parallel lines of small elongate inclusions aligned along crystallographic planes in the sphalerite, and as minute rounded blebs and small irregularly shaped areas ranging in size up to 0.15mm. (Plate 2, Nos. 1 and 2). The lines of inclusions are commonly between 0.1mm. and 0.4mm in length, with the individual blade-like inclusions rarely exceeding 0.05mm in length. Where the exsolved bodies are not oriented in lines, the random orientation and abundance is often sufficient to produce a "mottled" texture similar in appearance to those described by Edwards (1954, p. 99). Composite chalcocite-pyrrhotite inclusions are frequently observed.

The sphalerite from this locality is dark in hand specimen, indicating a high iron content.

Also present as inclusions within the sphalerite are

occasional round or ovate bodies of magnetite (Plate 1, No. 2). These inclusions have a maximum width of 0.05mm. No inclusions of other minerals were observed within the magnetite, but pyrrhotite occasionally occurs in the sphalerite on the magnetite-sphalerite borders.

The larger chalcopyrite areas contain inclusions of pyrrhotite. These inclusions vary considerably in shape and are up to 0.05mm in size, and show no particular orientation.

Pyrite is present as areas showing evidence of extensive replacement by sphalerite and chalcopyrite. Marcasite is present as a fine intergrowth with the pyrite in some parts.

Galena is not common in this specimen but occurs as occasional small patches which have apparently replaced pyrite, and sphalerite. The maximum width of these areas is 1mm. Boulangerite was noted as rare fine inclusions within the galena.

The samples collected from the dump consist largely of pyrite, but also contain small amounts of sphalerite, chalcopyrite and galena, and a trace of pyrrhotite. These minerals exhibit similar textural relationships to those described for the above specimen. Marcasite, magnetite and boulangerite were not detected in polished sections of these samples.

Assemblages of ore minerals.

Common: Chalcopyrite - sphalerite
Pyrite - sphalerite
Pyrrhotite - sphalerite
Chalcopyrite - pyrrhotite - sphalerite
Chalcopyrite - pyrrhotite

Infrequent: Chalcopyrite - pyrite
Chalcopyrite - pyrite - sphalerite
Galena - pyrite
Galena - pyrite - sphalerite
Galena - sphalerite
Magnetite - sphalerite

Rare: Boulangerite - galena
Chalcopyrite - galena - sphalerite
Galena - pyrrhotite
Galena - pyrrhotite - sphalerite
Magnetite - pyrrhotite - sphalerite
Marcasite - pyrite.

Doric Prospect

The workings of what is known as the Doric Prospect are located in the north-western part of the Zeehan field, a little more than one mile north of the Comstock workings. Blissett (1962) has described the host rocks as black slate and pale quartzite of the Conah Quartzite and Slate.

Specimens of ore from the Doric Prospect consist largely of pyrite with sphalerite and galena in a gangue of siderite. Minor amounts of chalcopryite, pyrrhotite, marcasite and tetrahedrite were also observed in polished sections.

Pyrite is commonly present as massive material with sphalerite and galena occurring as patches, up to several centimetres across, and as narrow bands within the pyrite. The massive pyrite generally appears in polished section as aggregates of fine idiomorphic crystals ranging in size from 0.025 to 0.075mm, with interstitial fine siderite. Chalcopryite is occasionally associated with the pyrite as interstitial patches, and a little marcasite was observed as fine material intergrown with pyrite.

The sphalerite is similar to that described from the Silver Stream Mine and Comstock Mine. Abundant exsolution bodies of chalcopryite and pyrrhotite are again present in the sphalerite, both as small blade-like bodies aligned along crystallographic planes and as minute blebs randomly distributed. In some sections (eg. P324) these inclusions show a pattern of distribution ; areas where the sphalerite is

clouded by extremely fine (less than 0.001mm) bodies of chalcopyrite and pyrrhotite grade into areas where the inclusions are the blade-like type and are oriented in parallel lines.

The sphalerite again appears dark in hand specimens of the ore. Pyrite has apparently been partially replaced by the sphalerite.

Galena occurs as patches within the massive pyrite, and where it is in contact with pyrite and sphalerite it appears to have extensively replaced these minerals. Rare inclusions of tetrahedrite up to 0.01mm were observed within the galena.

Assemblages of ore minerals.

Common:	Pyrite - sphalerite
	Galena - pyrite
	Galena - sphalerite
	Chalcopyrite - sphalerite
	Pyrrhotite - sphalerite
	Galena - pyrite - sphalerite
Infrequent:	Chalcopyrite - pyrrhotite
	Galena - pyrrhotite - sphalerite
	Marcasite - pyrite
Rare:	Chalcopyrite - pyrite
	Galena - pyrrhotite
	Galena - tetrahedrite

Sylvester Mine.

The main workings of the Sylvester Mine are located on either side of the Trial Harbour road, approximately $\frac{3}{4}$ mile north-east from the Comstock Mine. The country rocks in the vicinity of these workings are slate, shale, quartzite, and greywacke of the Oonah Quartzite and Slate (Blissett, 1962).

Other workings in the area include those of the "pyromorphite lode" (Waller, 1904) which is located approximately 1 mile east-north-east from the main Sylvester workings. According to Waller this lode consisted of gossan with a large quantity of pyromorphite. Montgomery (1893) reported cerargyrite associated with the pyromorphite, and also described a vein of galena 18 inches in width. According to Montgomery, 38 tons of ore, assaying 40% to 50% lead and 76 ozs of silver per ton, were taken out. Petterd (1910) also recorded embolite, cerussite and matlockite in the Sylvester Mine workings. Although Petterd did not state in which workings these minerals were found, it is almost certain that he was referring to the pyromorphite lode.

Waller (1904) described the lode in the main workings, near the Trial Harbour road, as a "large pyritic lode..... carrying a good deal of galena and zinc blende." Apart from one specimen of galena from the collection of the Tasmanian Museum (X.2936) the only other specimens available for this examination were samples of material collected from the dumps by the main workings. These specimens consist largely of pyrite

with smaller amounts of sphalerite and galena, and agree essentially with Waller's description of the ore. Minor amounts of arsenopyrite, chalcopyrite and pyrrhotite in a quartz gangue were observed in polished sections of the specimens.

The pyrite and arsenopyrite are closely associated and occur as idiomorphic crystals ranging in size from 0.025mm up to 0.8mm. Although a minor constituent, arsenopyrite is more common in these specimens than in ores from most other mines in the Zeehan area.

Small crystals of pyrite, up to 0.075mm, were observed within larger arsenopyrite crystals, and the reverse relationship was also occasionally observed. Both pyrite and arsenopyrite have apparently undergone replacement by sphalerite and galena, and core-replacement textures were observed. In these textures the cores of the pyrite and arsenopyrite crystals are occupied by sphalerite and galena. Small inclusions of pyrrhotite (0.02mm) in the pyrite and arsenopyrite also appear to be core replacement textures.

The sphalerite in these specimens is dark in hand specimen. Although pyrrhotite and chalcopyrite exsolution bodies within the sphalerite are again common, they are less abundant than in sphalerite from the Comstock area. The pyrrhotite bodies, which range from 0.005mm up to 0.025mm, are generally larger than the chalcopyrite bodies, which are rarely larger than 0.01mm. The finer pyrrhotite and chalcopyrite bodies show

alignment along crystallographic planes.

Galena is not abundant in the specimens from the dumps, and occurs only as irregular patches up to several millimetres across. The galena has apparently replaced sphalerite as well as the pyrite and arsenopyrite. Tetrahedrite, boulangerite, and bournonite were not observed in these specimens.

Specimen X.2936, from the Tasmanian Museum collection, consists of massive coarse-grained galena with minor sphalerite and pyrite. The galena differs from that observed in the dump material in that tetrahedrite and boulangerite were observed as occasional fine exsolution bodies within the galena. The tetrahedrite bodies are round and ovate and have a maximum size of 0.025mm. The boulangerite bodies are generally needle-shaped with a maximum length of 0.03mm, and also occasionally ovate with a maximum length of 0.015mm.

Sphalerite in this specimen is essentially similar to that described from the dump material, with the exception that the exsolution bodies of chalcopyrite and pyrrhotite are more abundant. In this respect this sphalerite closely resembles that from the Comstock Mine.

Assemblages of ore minerals.

Common:

Pyrite - sphalerite
 Galena - pyrite
 Pyrrhotite - sphalerite
 Chalcopyrite - sphalerite
 Galena - sphalerite
 Galena - pyrite - sphalerite

Infrequent:

Arsenopyrite - galena
 Arsenopyrite - galena - sphalerite
 Arsenopyrite - pyrite
 Arsenopyrite - pyrite - sphalerite
 Arsenopyrite - pyrrhotite
 Arsenopyrite - sphalerite
 Boulangerite - galena
 Chalcopyrite - pyrrhotite - sphalerite
 Galena - tetrahedrite
 Pyrite - pyrrhotite

Rare:

Chalcopyrite - pyrite
 Galena - pyrrhotite
 Galena - pyrrhotite - sphalerite
 Galena - sphalerite - tetrahedrite

Boss Mine.

The Boss Mine workings are located slightly less than $\frac{1}{4}$ mile east of the Comstock Mine. The workings occur in quartzite, slate, and phyllite of the Oonah Quartzite and Slate, (Blissett, 1962).

Reports by Twelvetrees (1901a) and Waller (1903) refer to three lodes in these workings. Waller (1903) described the "Main Lode" as consisting largely of pyrite with "in places a good deal of blende and galena". The "West Lode" was described by Waller as a large outcrop of gossan, and there is no record of workings other than a shallow adit. Twelvetrees (1901a) described the "East Lode" as containing sphalerite and pyrite with some galena. According to Twelvetrees, this galena was reputed to contain up to 105 ozs. per ton of silver.

Specimens collected from the dumps of the Boss Mine consist essentially of pyrite in a gangue of quartz, but contain minor sphalerite and galena.

The pyrite occurs as masses of idiomorphic crystals ranging in size from 0.02mm. up to 0.5mm and surrounded by quartz. The crystals of pyrite occasionally show a well defined zoning (Plate 2, No. 1), which is revealed by lines of minute inclusions (P.327). Sphalerite appears to have partially replaced the pyrite, and both minerals have apparently undergone replacement by galena. Some pyrite crystals exhibit core-replacement textures, suggesting that sphalerite has replaced

the central regions of the pyrite crystals.

The sphalerite is dark in hand specimens. Exsolution bodies are rare in the sphalerite in these specimens, the only such bodies observed being fine blade-like inclusions of chalcopyrite between 0.001 and 0.002mm in length, and similarly shaped bodies of pyrrhotite up to 0.005mm in length.

Galena is not common in these specimens and contains no associated tetrahedrite, boulangierite or bournonite. The galena occurs as patches up to a few centimetres across, these patches containing what appear to be remnants of extensively replaced sphalerite and pyrite.

Assemblages of ore minerals.

Common:	Pyrite - sphalerite
Infrequent:	Galena - pyrite
	Galena - pyrite - sphalerite
	Galena - sphalerite
Rare:	Pyrrhotite - sphalerite
	Sphalerite - chalcopyrite

Susannite (Britannia Extended) Mine

The Susannite Mine, also known as the Britannia Extended Mine, is located approximately $\frac{1}{4}$ mile east of the Boss Mine. Country rocks are similar to those at the Boss Mine.

Waller (1903) and Twelvetrees and Ward (1910) referred to two ore bodies in the mine workings. Waller (1903) described the western lode as consisting of gossan and pyrite with small seams of galena associated with cerussite and anglesite. According to Waller, the galena occurred in two forms, one a "dense fine-grained galena" carrying about 50ozs. of silver per ton, the other a "pure cubical ore" containing over 100 ozs. per ton of silver.

Twelvetrees and Ward (1910) described the eastern lode as a pyritic lode containing anglesite, campylite (a variety of mimetite) and cerussite. According to Twelvetrees (1901a), this ore was reputed to assay up to 116 ozs. of silver per ton.

The only material now to be found around the workings of this mine consists of decomposed pyrite and earthy iron oxide.

Britannia Mine

The Britannia Mine workings are located approximately $\frac{1}{4}$ mile east of the Susannite Mine and $\frac{1}{2}$ mile west of the junction of the Grubb's tram with the Comstock tram. The country rocks are part of the Conch quartzite and Slate and have been described by Blissett (1962) as "faulted and sheared Proterozoic micaceous quartzite, siltstone and slate or phyllite which is faulted against Cambrian greywacke and shale a short distance south of the Comstock tram."

Waller (1904) reported a large pyritic lode in the area as containing disseminated galena. Blissett (1962) referred to the lodes as "irregular veins and masses of pyrite and sphalerite with impersistent bands or disseminations of galena".

Twelvetreces (1901b) reported the presence of a suspected new mineral, petterdite, at the Britannia Mine, but Anderson (1908) later showed this to be a variety of mimetite. Petterd (1910) recorded the occurrence of campylite, another variety of mimetite, at the Britannia Mine.

Specimens collected from around the workings consist essentially of pyrite and sphalerite with minor galena in a gangue of quartz. Small amounts of arsenopyrite, chalcopyrite, pyrrhotite, tetrahedrite and boulangerite were also observed in polished sections of the ore.

Pyrite is present as massive material consisting of idiomorphic crystals, ranging in size from 0.01mm up to 0.5mm, surrounded by quartz. Arsenopyrite also occurs as idiomorphic

cryst ls which are often composite with pyrite. This pyrite - arsenopyrite association resembles that observed in specimens of ore from the Sylvester Mine. Both minerals appear to have undergone partial replacement by sphalerite and galena.

Sphalerite is ag in dark in hand specimen. Exsolution bodies of pyrrhotite and chalcopyrite are present but vary in abundance between specimens.

In some samples of ore (eg. P.329) the sphalerite contains only small amounts of these exsolution bodies, whereas in others (eg. P.332) the exsolution bodies are abundant. The pyrrhotite bodies are typically larger than those of chalcopyrite. Pyrrhotite ranges up to 0.02mm but the chalcopyrite is generally less than 0.01mm. The majority of these bodies lack orientation but in P.332 some of the chalcopyrite bodies are aligned along crystallographic planes in the sphalerite.

Galena forms areas up to several centimetres across and contains exsolution bodies of tetrahedrite and boulangerite. These are quite common in the galena in these specimens from the Britannia Mine. Tetrahedrite is present as round and ovate bodies up to 0.025mm, while boulangerite bodies show a variation in shape from ovate to needle-like. The ovate bodies of boulangerite have a maximum size of 0.05mm, and the needle-like bodies have a maximum length of 0.15mm. The boulangerite bodies show a sporadic distribution through the galena, and in some areas in the galena the minute needle-like bodies (less than 0.005mm in length) are abundant and

some show a parallel orientation.

The galena in these specimens exhibits a weak anomalous anisotropism, and appears to have partially replaced sphalerite as well as pyrite and arsenopyrite.

Assemblages of ore minerals.

Common:

Pyrite - sphalerite
Galena - pyrite
Galena - sphalerite
Galena - pyrite - sphalerite
Chalcopyrite - sphalerite
Pyrrhotite - sphalerite
Arsenopyrite - pyrite
Boulangerite - galena

Infrequent:

Arsenopyrite - galena
Arsenopyrite - galena - pyrite
Arsenopyrite - sphalerite
Galena - tetrahedrite

Rare:

Arsenopyrite - galena - sphalerite
Arsenopyrite - pyrite - sphalerite
Boulangerite - galena - tetrahedrite
Chalcopyrite - galena - sphalerite
Chalcopyrite - pyrrhotite - sphalerite
Galena - pyrrhotite - sphalerite
Galena - sphalerite - tetrahedrite
Sphalerite - tetrahedrite

T. L. E. Mine.

The workings known as the T. L. E. (Tasmanian Land Exploration Co.) Mine are situated near the Tasmanian tram, approximately $\frac{1}{2}$ mile east of the junction with the Trial Harbour road. Blissett (1962) has described the country rocks as "grey-wacke-conglomerate, grit, greywacke and shale considered to be part of the Cambrian Crimson Creek Formation".

Three lodes were encountered in the workings of the T. L. E. Mine. These are known as No. 1 (Main) Lode, No. 2 (Hughes') Lode, and No. 3 (Thurston's) Lode. According to Twelvetrees and Ward (1910) the lodes contained high grade sphalerite-galena ore which was regarded as the best ore in the Comstock district. Twelvetrees and Ward quoted galena assays of 75.4 to 76.5% lead and 105 to 111.8 ozs. silver per ton.

Samples of ore collected from surface dumps around the workings consist largely of sphalerite and galena with some pyrite in a quartz gangue. Pyrrhotite, chalcopyrite and marcasite were observed in polished sections. The sphalerite occurs as coarse patches, many of which are almost free of any inclusions of galena or pyrite greater than 1mm. The colour of the sphalerite is distinctly lighter than that from the Comstock Mine but darker than the sphalerite from the Swansea Mine.

Inclusions of galena, pyrite, pyrrhotite and chalcopyrite within the sphalerite are common but generally fine. The galena inclusions appear to represent an early stage of

replacement of the sphalerite, and the pyrite occurs mainly as crystals which have probably been partially replaced by sphalerite. Pyrite also occurs in some specimens of sphalerite (P. 243, 348) as narrow veinlets of very fine crystalline pyrite (Plate 3, No. 2). These veinlets are generally between 0.001 and 0.005mm. in width and rarely persist for more than 0.5mm. in total length.

Pyrrhotite and chalcopyrite are present as fine exsolution bodies within the sphalerite but vary considerably in abundance between specimens and within a single polished section. Pyrrhotite is the more abundant of the two minerals and occurs as bodies which are generally slightly larger than the chalcopyrite. The pyrrhotite bodies are mostly ovate or blade-like in shape with lengths between 0.005 and 0.01mm., while the chalcopyrite bodies are fine ovate blebs rarely greater than 0.005mm. in length. Both minerals are occasionally aligned along crystallographic planes in the sphalerite. In one specimen (P.347) the sphalerite shows evidence of fracturing, and chalcopyrite has been deposited in the fractures as bodies measuring 0.01mm. x 0.05mm.

The coarse areas of galena are mostly comparatively free from inclusions of other minerals, although P.350 consists of galena with abundant "remnant" inclusions of pyrite and sphalerite and occasional pyrrhotite. These minerals appear to have been extensively replaced by the galena in this specimen. No inclusions of tetrahedrite, boulangierite or bournonite were

observed within the galena, and these minerals were not observed at all in the specimens examined. The absence of tetrahedrite is surprising in view of the high silver assays quoted by Twelvetrees and Ward (1910). If the assays were reliable then it must be assumed that the distribution of tetrahedrite was rather patchy.

Pyrite occurs in the ore as areas up to several centimetres across, consisting of idiomorphic and subidiomorphic crystals, ranging in size from 0.02mm. up to 2.5mm. In some specimens (eg. P.350) a little fine marcasite is associated with the pyrite.

Assemblages of ore minerals.

Common:

Galena - sphalerite
Pyrite - sphalerite
Galena - pyrite
Galena - pyrite - sphalerite
Pyrrhotite - sphalerite
Chalcopyrite - sphalerite.

Infrequent:

Galena - marcasite - pyrite
Galena - pyrrhotite
Galena - pyrrhotite - sphalerite
Marcasite - pyrite

Rare:

Chalcopyrite - pyrrhotite - sphalerite

Stonehenge Mine

The workings of the Stonehenge Mine are located approximately 200 yds. south-east of the T. L. E. main shaft. The country rocks are as described for the T. L. E. Mine.

According to Twelvetrees and Ward (1910) the ore-body consisted of sphalerite with small amounts of pyrite and chalcopyrite, and galena occurred in bands and blebs. The gangue was described as being chiefly quartz with a little siderite. Assays of galena were quoted by Twelvetrees and Ward as giving 68% lead and 71ozs. silver per ton.

The material now present in the surface dumps is not truly representative of the ore extracted from the mine, as far as can be judged by comparison with the description by Twelvetrees and Ward (op. cit). Specimens selected from the dumps consist almost entirely of sphalerite and quartz. Minor amounts of galena can also be observed in hand specimen, and pyrite, pyrrhotite, chalcopyrite, tetrahedrite and boulangerite were detected in polished sections.

The sphalerite is identical in colour with that at the nearby T. L. E. Mine. Exsolution bodies of pyrrhotite form occasional patches in the sphalerite, but are not abundant. The shape of these bodies is generally ovate, and the lengths vary between 0.001mm. and 0.005mm. Chalcopyrite is rare and occurs only as 0.001mm. blebs in the sphalerite.

Galena is present within the sphalerite as areas up to 5mm. in width. The galena appears to have partially replaced

the sphalerite, and corroded "remnants" of sphalerite can be seen within the galena. Occasional ovate-shaped inclusions of pyrrhotite were also observed in the galena. Tetrahedrite is present as occasional small elongate bodies in the galena, the maximum size observed being 0.009mm. x 0.003mm. Rare boulangierite bodies, with a maximum size of 0.005mm. x 0.002mm. were observed in the galena.

As in the sphalerite from the T. L. E. Mine, two forms of pyrite were observed. The first form is represented by occasional patches of subidiomorphic crystals, rarely greater than 0.05mm. and showing signs of partial replacement by sphalerite. The second form is represented by very fine branching veinlets of crystalline pyrite. The maximum width of these veinlets is 0.005mm.

Assemblages of ore minerals.

Common:	Galena - sphalerite
Infrequent:	Galena - pyrite - sphalerite Galena - tetrahedrite Pyrite - sphalerite Pyrrhotite - sphalerite
Rare:	Boulangierite - galena Chalcopyrite - sphalerite Galena - pyrrhotite Galena - pyrrhotite - sphalerite

North Tasmanian Mine

The workings of the North Tasmanian Mine are located on the northern side of the Tasmanian tram, a little more than 1/2 mile south-east of the T. L. E. Mine. Blissett (1962) has described the ore bodies as fissure veins occurring in "contorted and shattered shale, siltstone and quartzite of the Oonah Quartzite and Slate". Blissett also reports that these rocks are faulted against Cambrian greywacke, grit and shale between the main shaft and the Tasmanian tram.

A total of five lodes have been reported (Taylor, 1953) in the workings of the North Tasmanian Mine, but of these the most important was the No.1 (North Tasmanian) Lode. Twelvetreets (1961a) described the ore from No.1 Lode as galena - sphalerite ore, and reported the following assays of ore sold to the Queensland Smelting Company.

	Ag (ozs. per ton)	Pb(%)
Kaolin and goossen ore	328	39
" "	87	7
" "	76	13
Galena, first quality	75	76
" "	70	74
" "	67	71
" "	65	73
Galena, second quality	54	61
" "	49	52
" "	44	66

Twelvetreets reported an assay of 124 ozs. silver^{per ton}, 79% lead for a further sample of galena. Nine assays of ore from No. 3 Lode were reported by Taylor (1954a) as follows.

Ag (ozs. per ton)	Pb%	Zn%
1. 6	19.5	1.3
1. 3	15.6	5.6
3. 5	30.5	37.0.
8. 2	70.4	4.7
6. 8	34.8	0.7
3. 5	32.0	23.1
2. 6	6.5	20.4
5. 9	52.9	13.2
5. 7	52.2	13.7

Specimens collected from surface dumps in the vicinity of the workings consist largely of galena and sphalerite in a gangue of siderite and quartz. Other minerals observed in polished sections were boulangerite, bournonite, pyrite, chalcopyrite and arsenopyrite.

The dominant mineral in these samples is galena, which occurs as massive material containing inclusions of the other minerals. The galena shows a weak anomalous anisotropism and appears to have extensively replaced the sphalerite, pyrite and arsenopyrite, and to have also partially replaced the chalcopyrite. In some areas, fine inclusions of sphalerite are abundant in the galena, apparently as remnants of replacement.

Boulangerite inclusions are very common in the galena and are taken, by analogy with boulangerite - galena assemblages elsewhere in the Zechen area, to be exsolution bodies in the galena host. These bodies of boulangerite vary considerably in shape. Most of the bodies have smooth outlines but the overall shapes vary from ovate to round and others are quite irregular. The maximum size observed was 0.1mm. x 0.05mm., but the majority were less than 0.05mm. in maximum dimension.

Bournonite inclusions are also moderately common in the galena. These inclusions are round and ovate in shape, and range in size from 0.05mm. to 0.06mm.

Sphalerite in these specimens is a slightly lighter colour in hand specimen than the sphalerite at the T. L. E. Mine and Stonehenge Mine, but is still considerably darker than that at the Swansea Mine.

Pyrrhotite was not observed in polished sections of these specimens. Chalcopyrite is present in small amounts but is not common as exsolution bodies within the sphalerite. Occasional areas of sphalerite can be seen to include very fine ovate blebs (0.001 to 0.002mm.) of exsolved chalcopyrite, and chalcopyrite is also present as inclusions in the galena.

These inclusions are of irregular outline and show evidence of partial replacement by the galena. The largest such inclusion observed was 0.025mm. x 0.01mm.

Pyrite occurs as occasional subidiomorphic crystals (0.01mm to 0.075mm) within sphalerite and galena, and has apparently undergone replacement by both minerals.

Arsenopyrite is present both as fine idiomorphic crystals within, and apparently extensively replaced by, galena, and also occurs as occasional clusters of fine crystals within the gangue constituents.

Assemblages of ore minerals.

Common: Galena - sphalerite
Boulangerite - galena
Bournonite - galena

Infrequent: Arsenopyrite - galena
Arsenopyrite - galena - sphalerite
Arsenopyrite - sphalerite
Boulangerite - galena - sphalerite
Chalcopyrite - galena
Galena - Pyrite
Galena - pyrite - sphalerite
Pyrite - sphalerite

Rare: Boulangerite - galena - pyrite
Chalcopyrite - galena - sphalerite
Chalcopyrite - sphalerite

Tasmanian Mine.

The workings of the Tasmanian Mine are located approximately 700 yards south-east of the North Tasmanian Mine. Blissett (1962) has reported that "the northern part of the workings lies within sheared and shattered Proterozoic quartzite, siltstone and shale, which are faulted to the south against Cambrian chert-conglomerate and siltstone overlain by small patches of Permian tillite".

Montgomery (1893) described the ore as "patchy" and containing "a good deal of blende with galena". According to Montgomery, the average assay of the 870 tons mined before March 6th, 1893, was 64% lead and 36ozs. silver per ton. Waller (1904) reported that ore from the Tasmanian Mine contained pyrite and siderite with "a good deal of zinc-blende".

The mineralogy of specimens collected from surface dumps in the area varies considerably between specimens. Pyrite and galena are the most common minerals and are associated with a gangue of siderite and quartz. Sphalerite occurs as occasional patches in the pyrite and galena, and minor amounts of chalcopyrite, tetrahedrite and boulangerite were also observed in polished sections.

Pyrite commonly occurs as massive material in which the form of the individual crystals varies from idiomorphic to allotriomorphic. The idiomorphic and subidiomorphic crystals are generally less than 0.1mm. in size, and show evidence of extensive peripheral replacement by galena, chalcopyrite,

tetrahedrite and sphalerite. These minerals appear to have also partially replaced pyrite along fractures in the allotriomorphic areas. Some of the specimens collected were found to consist almost entirely of pyrite and siderite (eg. P.358).

Galena occurs as irregularly shaped patches up to several centimetres in overall width. Boulangerite and tetrahedrite are associated with the galena, but the distribution is very sporadic. In P.356 boulangerite occurs in some areas of galena as abundant blade-like bodies up to 0.075 mm. in length. Some of these bodies show alignment along crystallographic planes in the galena. Tetrahedrite was not observed in P. 356, but is quite common in P.357 in association with galena and chalcopyrite. The tetrahedrite rarely forms fine inclusions within the galena but commonly occurs as areas of irregular outline with a maximum overall width of 0.25mm.

The sphalerite visible in hand specimen is similar in colour to that from the North Tasmanian Mine. Galena has apparently replaced the sphalerite where the two minerals are in contact. Inclusions of chalcopyrite within the sphalerite are common as very fine blebs, most of which are less than 0.005mm. and some of which show alignment along crystallographic planes in the sphalerite. Pyrrhotite is rare, and occurs only as ovate-shaped bodies, up to 0.02mm. in length, within the sphalerite (P.356).

Chalcopyrite also occurs as areas up to 0.5cm. in overall width (P.357). In these larger areas of chalcopyrite,

fine exsolution bodies of sphalerite were observed (Plate 4, No. 1). These bodies are generally star-shaped but some have a shape resembling that of a hollow square, and the maximum size of either type is 0.006mm.

Assemblages of ore minerals.

Common:

Galena - pyrite
 Pyrite - sphalerite
 Galena - sphalerite
 Galena - pyrite - sphalerite
 Chalcopyrite - sphalerite
 Boulangerite - galena
 Galena - tetrahedrite

Infrequent:

Chalcopyrite - galena
 Chalcopyrite - galena - pyrite
 Chalcopyrite - galena - sphalerite
 Chalcopyrite - tetrahedrite
 Chalcopyrite - galena - tetrahedrite
 Pyrite - tetrahedrite

Rare:

Galena - pyrite - tetrahedrite
 Galena - pyrrhotite - sphalerite
 Pyrrhotite - sphalerite

Swansea Mine

The workings of the Swansea Mine are located approximately $\frac{1}{2}$ mile south-east of the Tasmanian Mine. According to Blissett (1962) the country rocks consist of "contorted hard black shale or slate, pale fine to fairly coarse quartzite riddled with thin veins of milky quartz, and a band of pale conglomerate which is well exposed in the water wheel cutting". Blissett has placed the beds in either the upper part of the Oonah Quartzite and Slate or the lower part of the Crimson Creek Formation.

Reid (1922, 1925) and Nye (1929) have described the workings of the Swansea Mine. According to Nye there are three lodes, known as Hill's Lode, Murphy's Lode and Main Lode. Reid (1925) described the ore bodies as occurring within a lode channel 32 feet in width and over 1,200 feet in length. The individual ore shoots were up to about 110 feet in length and were reported to course obliquely across the lode channel.

Reid (1925) described the chief mineral components of the ore as galena (argentiferous), sphalerite, tetrahedrite and chalcopyrite. An estimate by Reid gave the average composition of the galena produced up to 1925 as 60% lead and 15 ozs. of silver per ton, and the sphalerite for the same period as 47% zinc and 2% cadmium. Reid also estimated that ore on hand at the time (i.e. 1925) was 50 tons of lead ore (Containing 60% lead, 16ozs. silver per ton), 200 tons of

zinc-lead ore (containing 30% zinc, 20% lead, 9ozs. of silver per ton) and 200 tons zinc ore (containing 45% zinc.)

An electron-probe micro-analysis* of the trace element composition of a sample of pure coarse sphalerite from the Swansea Mine gave the following result.

Fe: 0.7%
Cd: 0.15%
Mn: 0.005%

The figure of 2% cadmium quoted by Reid (op.cit) would appear to be very high and does not agree with the above analysis, or with the analysis included in Table 11 (see p. 140) of sphalerite from a pyrite - sphalerite assemblage.

Specimens of ore collected from the surface dumps consist of coarse yellow-brown sphalerite, galena (most of which has tarnished to an iridescent blue colour), decomposed pyrite, and bournonite, with a gangue of siderite and a little quartz. Smaller amounts of tetrahedrite, chalcopyrite and arsenopyrite were also noted in polished sections of the specimens. It is likely that at least some of the "tetrahedrite" reported by Reid (1925) was bournonite. No tetrahedrite was noted in hand specimen proportions in this present study, whereas bournonite was found to be a prominent constituent of several hand specimens, including one specimen incorrectly labelled as "tetrahedrite" (P.237) in the collection of the Tasmanian Department of Mines.

The pale yellow-brown colour of the sphalerite in hand

* Analysis by Mr. P. Schultz, Australian Mineral Development Laboratories, Adelaide, South Australia.

specimen is very distinctive, the colour being the lightest observed for sphalerite in the Zeehan area. The specimens of coarse sphalerite (P.25,105) are almost entirely free of other minerals, except for a little siderite which is present as occasional small crystals and narrow veinlets within the sphalerite. Small areas of sphalerite also commonly occur within siderite (P.116) and galena (P.182, 184) and sphalerite is less commonly associated with bournonite and tetrahedrite (P. 369). Occasional minute elongate exsolution bodies of chalcopyrite were observed within the sphalerite. Most of these bodies are less than 0.001mm. in length and exhibit random orientation. The sphalerite in the galena-sphalerite assemblages appears to have undergone extensive replacement by the galena.

The galena-rich specimens (eg. P.104, 182) consist essentially of medium-grained galena associated with bournonite, sphalerite, tetrahedrite and the siderite gangue. Bournonite is closely associated with the galena and often occurs as small areas, up to several millimetres in overall width, within the galena. Bournonite was also observed within the galena as small bodies showing a variation in shape from round and ovate to irregular and a size range of 0.02mm. to 0.06mm. These small bodies are considered to be exsolution bodies in the galena host, and occasional composite bournonite - tetrahedrite bodies were noted. Bournonite also occurs intimately associated with the galena as a fine intergrowth, (P.369), the texture at times resembling in appearance the graphic inter-

growth textures illustrated by Edwards (1954).

Occasional specimens from the Swansea Mine consist of patches of massive bournonite in siderite (P.237,361). These areas of bournonite contain small irregularly shaped inclusions of galena, tetrahedrite, chalcopyrite and sphalerite, and occasional fine idiomorphic and subidiomorphic crystals of pyrite and arsenopyrite.

Tetrahedrite is common as a minor constituent of the galena- and bournonite-rich material. These inclusions of tetrahedrite in galena and bournonite are of irregular outline and vary in size from small bodies of 0.005mm. width up to areas 0.1mm. in overall width. Tetrahedrite occasionally appears to have partially replaced sphalerite (P.182).

Pyrite is not commonly associated with the other ore minerals but is frequently associated with the non-metallic minerals. Fine inclusions (0.02mm.) of pyrite were observed within euhedral quartz crystals. Small amounts of pyrite were noted within galena, bournonite and sphalerite as fine idiomorphic and subidiomorphic crystals.

Arsenopyrite was also noted as fine crystals within galena and bournonite. Both the pyrite and arsenopyrite appear to have undergone replacement by galena.

Assemblages of ore minerals.

Common:

Galena - sphalerite
 Bournonite - galena
 Galena - tetrahedrite

Infrequent:

Arsenopyrite - bournonite
 Arsenopyrite - galena
 Bournonite - chalcopyrite
 Bournonite - galena - sphalerite
 Bournonite - galena - tetrahedrite
 Bournonite - pyrite
 Bournonite - tetrahedrite
 Chalcopyrite - sphalerite
 Galena - pyrite
 Galena - pyrite - sphalerite
 Galena - sphalerite - tetrahedrite
 Pyrite - tetrahedrite

Rare:

Bournonite - galena - pyrite
 Bournonite - pyrite - tetrahedrite
 Bournonite - chalcopyrite - sphalerite
 Chalcopyrite - tetrahedrite
 Galena - pyrite - tetrahedrite

Silver Duke Prospect

The Silver Duke Prospect is situated approximately 1,000 yards south-east of the Swansea Mine. No ore was produced but, according to Blissett (1962), small amounts of galena, sphalerite, pyrite and chalcopyrite have been found in quartz and siderite in a fault zone which was intersected in two adits.

Reid (1922) reported the occurrence of small amounts of the nickel-bearing minerals genthite, millerite and pentlandite in a narrow pyroxenite dyke located between the Silver Duke Prospect and the Swansea Mine.

Grubb's Mine.

The workings of the Grubb's Mine (occasionally referred to as the Colonel North Mine) are located approximately $\frac{1}{2}$ -mile north-east of the Swansea Mine. The workings are at the terminus of the abandoned Grubb's tram, which joined the Comstock tram approximately $\frac{3}{4}$ -mile west of Manganese Hill. Blissett (1962) has described the country rocks in the vicinity of Grubb's Mine as shale, slate and pale quartzite or sandstone which are part of the Conah Quartzite and Slate.

Descriptions of the workings were given in reports by Montgomery (1893), Twelvetreces (1901a), Waller (1904) and Twelvetreces and Ward (1910). These reports indicate that the mineralization consisted essentially of galena and sphalerite with some pyrite in a gangue of siderite and quartz. The ratio of galena to sphalerite apparently varied considerably but the two minerals were often intimately mixed, making separation difficult. The proportion of sphalerite was reported to increase with depth. Assays of ore quoted in the above reports cover a range of 20 to 80% lead and 20 to 120ozs. silver per ton. The highest silver values were apparently recorded in ore extracted from the workings above No.2 Level (200 feet).

Petterd (1910, p.58) referred to an unconfirmed report of crocoite at the Colonel North (Grubb's) Mine. According to this report, crocoite was found in very limited quantity as small crystals in gossan. In the absence of any further

reports, this is regarded as a doubtful occurrence.

Specimens in the Tasmanian Museum collection and specimens collected from the surface dumps near the main shaft, confirm the reported variation in the galena: sphalerite ratio. The proportions of the two minerals show a variation from predominantly galena to predominantly sphalerite.

In addition to galena and sphalerite, pyrite and bournonite were noted in some hand specimens, and boulangerite, tetrahedrite, pyrrhotite and pyrargyrite were also observed in polished sections of the specimens. Although siderite was reported to be the main gangue constituent (Twelvetrees 1901a, Twelvetrees and Ward 1910), quartz is the more common non-metallic mineral present in these specimens. Twelvetrees and Ward (1910) also recorded barite in quartz in a crosscut on No. 4 Level (324 feet). One specimen of barite (X.3048), measuring approximately 2" x 1½" x 1", present in the Tasmanian Museum collection is labelled "Grubb's Mine" and is probably from the crosscut described by Twelvetrees and Ward.

As described above, some specimens (eg. P.222, 236) consist almost entirely of galena with only minor amounts of sphalerite. In these specimens the sphalerite occurs as inclusions within the galena and shows evidence suggestive of extensive replacement by the galena. Boulangerite is associated with the galena in all specimens examined, and occurs as bodies showing a variation in shape from round and ovate to blade-like and needle-like (Plate 4, No.2). The round and ovate bodies range in size from minute blebs as fine as

0.005mm. up to bodies 0.05mm. in maximum diameter. The blade- and needle-like bodies have a maximum length of 0.08mm. Some of these bodies show an alignment along crystallographic planes in the galena.

Bournonite and tetrahedrite are also associated with the galena but the distribution is much more sporadic than that of the boulangerite. Both minerals occur within the galena and occasionally form composite inclusions with boulangerite. Bournonite is present in one specimen as an area one centimetre across (P.222); this area contains small inclusions of galena, boulangerite and tetrahedrite. The more common mode of occurrence for the bournonite is as small (0.02mm) ovate bodies which occur within the massive galena (eg. P.236).

The tetrahedrite inclusions in the galena (eg. P.374) vary in shape from round to irregular and show a variation in size from 0.005mm. up to 0.13mm.

Pyrrargyrite was observed as rare inclusions, of irregular outline and up to 0.025mm. in width, within galena in P.374. Rare composite boulangerite-pyrrargyrite inclusions were also observed.

The sphalerite-rich samples (eg. P.335,336) contain galena as irregularly shaped inclusions within the massive sphalerite. The relationship is indicative of incipient replacement of the sphalerite. Pyrite is not common in the massive galena, and occurs only as small (0.01mm. to 0.075mm)

idiomorphic crystals showing apparent extensive replacement by the galena, but pyrite is commonly associated with the massive sphalerite. Pyrite also occurs occasionally as massive patches up to several centimetres in P.337. Sphalerite appears to have partially replaced the pyrite.

The sphalerite is dark in hand specimen, the colour being similar to sphalerite from the T. L. E. Mine and Britannia Mine. Pyrrhotite exsolution bodies are common in some specimens (eg. P.374) but not in others (eg. P.335). These bodies are mostly small elongate blebs with a maximum length of 0.02mm, and are occasionally aligned along crystallographic planes. Chalcopyrite exsolution bodies in the sphalerite are not common but were observed as occasional patches of very fine (0.003mm. and less) blebs showing random orientation in P.334 and 374.

Assemblages of ore minerals.

Common:

Galena - sphalerite
 Pyrite - sphalerite
 Boulangerite - galena
 Pyrrhotite - sphalerite
 Bournonite - galena

Infrequent:

Boulangerite - bournonite
 Boulangerite - bournonite - galena
 Boulangerite - galena - sphalerite
 Boulangerite - tetrahedrite
 Chalcopyrite - sphalerite
 Galena - pyrite
 Galena - pyrite - sphalerite
 Galena - tetrahedrite

Rare:

Boulangerite - galena - pyrargyrite
 Boulangerite - galena - tetrahedrite
 Bournonite - galena - tetrahedrite
 Galena - pyrargyrite
 Galena - pyrite - tetrahedrite
 Galena - sphalerite - tetrahedrite